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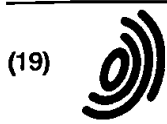
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• Kato, Hideyuki
Murata Manufacturing Co., Ltd.
Nagaokakyo-shi, Kyoto-fu 617-8555 (JP)
• Matsumoto, Haruo
Murata Manufacturing Co., Ltd.
Nagaokakyo-shi, Kyoto-fu 617-8555 (JP)

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(71) Applicant:
Murata Manufacturing Co., Ltd.
Nagaokakyo-shi Kyoto-fu 617-8555 (JP)

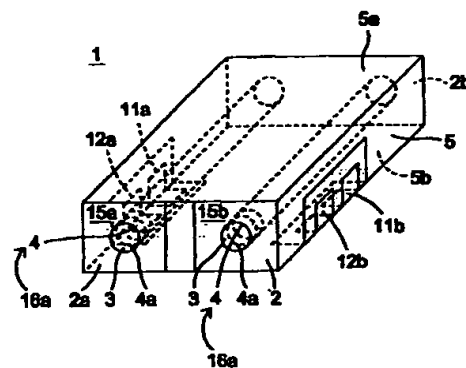
(74) Representative:
Schoppe, Fritz, Dipl.-Ing.
Schoppe & Zimmermann
Patentanwälte
Postfach 71 08 67
81458 München (DE)

(72) Inventors:
• Toda, Jun
Murata Manufacturing Co., Ltd.
Nagaokakyo-shi, Kyoto-fu 617-8555 (JP)

(54) Dielectric filter and dielectric duplexer

(57) The invention provides a dielectric filter (1), comprising: a dielectric block (2) having substantially rectangular shape, said dielectric block (2) including a first and a second surfaces (2a, 2b) opposed to each other and a third and a fourth surfaces opposed to each other and extending between said first and second surfaces (2a, 2b); a plurality of through holes (3) extending between said first and second surfaces (2a, 2b); an inner conductor (4) provided on an inner surface of said through holes (3) except for a non-conductive portion (4a), said non-conductive portion (4a) being disposed on said inner surface of said through holes (3) in the vicinity of said first surface (2a) of said dielectric block (2); an outer conductor (5) provided on said third and fourth surfaces of said dielectric block (2); and a line conductor (7) provided on said first surface (2a) of said dielectric block (2), a part (5a) of said outer conductor (5) provided on said third surface of said dielectric block (2) and a part (5b) of said outer conductor (5) provided on said fourth surface of said dielectric block (2) being connected to each other via said line conductor (7); thereby a plurality of resonators (15a, 15b, 16a, 16b) comprising a combination of a TEM mode resonator and a TE mode resonator, or a combination of a TEM mode resonator or a TM mode resonator being provided.

FIG.1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a dielectric filter and a dielectric duplexer, more specifically, a dielectric filter and a dielectric duplexer for the dual band to be used in a communication devices etc., for the microwave band and the millimeter wave band.

2. Description of the Related Art

[0002] In a construction of a high frequency circuit part for the dual band to be used for a communication device for the microwave band or the millimeter wave band, such a circuit part has been constituted by combining two band pass filters 101, 121 shown in FIGs. 10 and 11. The band pass filter 101 shown in FIG. 10 is provided with three resonators utilizing a TEM mode.

[0003] In FIG. 10, the high frequency circuit part comprises a dielectric block 102, through holes 103 in which an inner conductor is provided on an inner wall surface, electrode patterns 104 for regulating the respective resonance frequency of TEM mode resonators and the electromagnetic coupling therewith, an outer conductor 105 provided on an outer surface of the dielectric block 102 except for an open end surface 102a, and input/output electrodes 106 for TEM mode.

[0004] The band pass filter 121 shown in FIG. 11 is provided with three resonators utilizing a TE mode. In FIG. 11, the band pass filter is provided with a dielectric block 122, a line conductor 123 for TE mode coupling, outer conductors 124a, 124b which are provided on upper and lower surfaces of the dielectric block 122 and electrically connected to each other via the line conductor 123, and input/output electrodes 125 for TE mode.

[0005] Apart from the above described structure, there are some cases where the high frequency circuit part for the dual band comprises the band pass filter of one-input/two-output type making use of a duplexer.

[0006] However, in either case, there is a problem that a space to be occupied by two band pass filters is required when the above described filter are mounted on a printed circuit board, etc.

[0007] To solve this problem, a composite parts miniaturized by integrating the TEM mode band pass filter 101 and the TE mode band pass filter 121 which are illustrated in FIGs. 10 and 11 respectively, can be designed. However, only by integrating the TEM mode band pass filter 101 and the TE mode band pass filter 121, the line conductor 123 for the TE mode coupling is required to be obtained between the electrode patterns 104 formed on the open end surface 102a of the TEM mode band pass filter 101, and the electromagnetic coupling of the TEM mode resonators with each other is affected by the line conductor 123. Thus, it is difficult to

independently design the TEM mode band pass filter and the TE mode band pass filter. In addition, the electrode patterns 104 are provided on the open end surface 102a, and the forming position of the line conductor 123 is limited to the prescribed part of the open end surface 102a, raising a new problem that the resonance frequency of the TE mode resonator and the setting of the number of the resonators are restricted.

10 SUMMARY OF THE INVENTION

[0008] Preferred embodiments of the present invention are provided to overcome the above described problems, and provide a compact dielectric filter and a compact dielectric duplexer for the dual band with which a built-in resonator of each mode can be independently designed.

[0009] The preferred embodiment of the present invention provides a dielectric filter, comprising: a dielectric block having substantially rectangular shape, said dielectric block including a first and a second surfaces opposed to each other and a third and a fourth surfaces opposed to each other and extending between said first and second surfaces; a plurality of through holes extending between said first and second surfaces; an inner conductor provided on an inner surface of said through holes except for a non-conductive portion, said non-conductive portion being disposed on said inner surface of said through holes in the vicinity of said first surface of said dielectric block; an outer conductor provided on said third and fourth surfaces of said dielectric block; and a line conductor provided on said first surface of said dielectric block, a part of said outer conductor provided on said third surface of said dielectric block and a part of said outer conductor provided on said fourth surface of said dielectric block being connected to each other via said line conductor; thereby a plurality of resonators comprising a combination of a TEM mode resonator and a TE mode resonator, or a combination of a TEM mode resonator or a TM mode resonator being provided.

[0010] In the above described dielectric filter, instead of the line conductor, at least one of a coupling means and a coupling groove may be provided. Said coupling means extends between said third and fourth surfaces of said dielectric block, and a part of said outer conductor provided on said third surface of said dielectric block and a part of said outer conductor provided on said fourth surface of said dielectric block are connected to each other via said coupling means. Said coupling groove is disposed on said first and second surfaces of said dielectric block and extends between said third and fourth surfaces of said dielectric block; thereby a plurality of resonators comprising a combination of a TEM mode resonator and a TE mode resonator, or a combination of a TEM mode resonator or a TM mode resonator being provided.

[0011] The above described coupling means may

comprises a through hole for coupling extending between said third and fourth surfaces of said dielectric block and an inner conductor provided on an inner surface of the through hole. A part of said outer conductor provided on said fourth surface of said dielectric block are connected to each other via said inner conductor.

[0012] In the above described dielectric filter, said non-conductive portion may be also disposed on said inner surface of said through holes in the vicinity of said second surface of said dielectric block.

[0013] The above described dielectric filter may further include a fifth and a sixth surfaces opposed to each other and extending between said first and second surfaces; and input/output external electrodes may be provided on said fifth and sixth surfaces of said dielectric block.

[0014] The above described structure of the dielectric filter may be applied to a dielectric duplexer as well.

[0015] According to the above structure, a plurality of through holes and their inner conductors, together with the outer conductors and the dielectric block, constitute a plurality of TEM mode resonators. On the other hand, the line conductor, the coupling means such as the through hole for coupling, and the groove function as the coupling susceptance, while the outer conductors and the dielectric block constitute a plurality of TE mode resonators or TEM mode resonators divided by the line conductor, the coupling means and the groove.

[0016] Further, the inner conductors provided on the inner wall surface of the through holes are also provided with the non-conductive portion in the vicinity of the second surface of the dielectric block, and the TEM mode resonator becomes the resonator of 1/2 wavelength.

[0017] Because the non-conductive portion to regulate the respective resonance frequencies of the TEM mode dielectric resonators and the electromagnetic coupling therewith is provided in the through holes, an electromagnetic affection by the line conductors, coupling means and the groove is suppressed. As a result, a compact dielectric filter or dielectric duplexer for dual band capable of independently designing a built-in resonator of each mode, can be obtained.

[0018] Other features and advantages of the present invention will become apparent from the following description of preferred embodiments of the invention which refers to the accompanying drawings, wherein like reference numerals indicate like elements to avoid duplicative description.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

FIG. 1 is a perspective view illustrating a first preferred embodiment of a dielectric filter of the present invention.

FIG. 2 is an electric equivalent circuit of the dielectric filter illustrated in FIG. 1.

FIG. 3 is a graph to indicate the attenuation characteristic of the dielectric filter illustrated in FIG. 1.

FIG. 4 is a perspective view illustrating a second preferred embodiment of the dielectric filter of the present invention.

FIG. 5 is an electric equivalent circuit of the dielectric filter illustrated in FIG. 4.

FIG. 6 is a perspective view illustrating a third preferred embodiment of the dielectric filter of the present invention.

FIG. 7 is an electric equivalent circuit of the dielectric filter illustrated in FIG. 6.

FIG. 8 is a perspective view illustrating an preferred embodiment of a dielectric duplexer of the present invention.

FIG. 9 is an electric equivalent circuit of the dielectric duplexer illustrated in FIG. 8.

FIG. 10 is a perspective view illustrating a dielectric filter of the conventional TEM mode.

FIG. 11 is a perspective view illustrating a dielectric filter of the conventional TE mode.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[First Preferred Embodiment, FIG. 1 through FIG. 3]

[0020] As illustrated in FIG. 1, a dielectric filter 1 is provided with a rectangular parallelepiped dielectric block 2 made of the dielectric material. A plurality of through holes 3 (two holes in the first embodiment) extending between a first surface 2a and a second surface 2b which is opposed to the first surface 2a of the dielectric block 2. Inner conductor 4 are provided respectively on inner wall surfaces of the through holes 3, and the inner conductors 4 are provided with non-conductive portions 4a in the vicinity of the first surface 2a.

[0021] Outer conductors 5 are provided on an outer wall surface of the dielectric block 2 except for the first surface 2a. That is, the outer conductors 5 are electrically opened (disconnected) from the inner conductors 4 on the first surface 2a (hereinafter, referred to as "the open end surface 2a") of the dielectric block 2, and electrically short-circuited (conducted) to the inner conductors 4 on the second surface 2b (hereinafter, referred to as "the short-circuited end surface 2b").

[0022] Further, a line conductor 7 leading from the first surface 2a of the dielectric block 2 to the second surface 2b is provided on the open end surface 2a between the through holes 3. The line conductor 7 electrically connects an outer conductor portion 5a provided on the upper surface (third surface) of the dielectric block 2 to an outer conductor portion 5b provided on the lower surface (fourth surface) thereof on the open end surface 2a. A TE mode input electrode 11a, a TE mode input electrode 12a, a TE mode output electrode 11b, and a TE mode output electrode 12b are formed respec-

tively on right and left side surfaces (fifth and sixth surfaces) of the dielectric block 2 with a gap between them and the outer conductors 5.

[0023] Two through holes 3 and their inner conductors 4, together with the outer conductors 5 and the dielectric block 2, constitute two TEM mode dielectric resonators 16a, 16b of $1/4$ wavelength with the open end surface 2a and the short-circuited end surface 2b of the dielectric block 2 as the open surface and the short-circuited surface. The TEM mode dielectric resonators 16a, 16b are electromagnetically coupled with each other to form a two-stage band pass filter of the TEM mode.

[0024] The line conductor 7 provided on the open end surface 2a of the dielectric block 2 works as the coupling susceptance. Thus, the outer conductors 5 and the dielectric block 2 constitute two TE mode dielectric resonators 15a, 15b (preferably of the mode of low order such as TE_{101}, TE_{102}) divided by the line conductor 7. The TE mode dielectric resonators 15a, 15b are electromagnetically coupled with each other through the line conductor 7 to form a two-stage band pass filter of the TE mode. That is, the line conductor 7 not only electromagnetically couple the dielectric resonators 15a, 15b of the TE mode, but also functions as an electromagnetic boundary part with the large reflection coefficient of the resonators 15a, 15b.

[0025] FIG. 2 is an electric equivalent circuit of the dielectric filter 1. The dielectric filter 1 is a dual band dielectric filter of two-input and two-output in which the TEM mode band pass filter and the TE mode band pass filter are built in. That is, as illustrated in FIG. 3, the dielectric filter 1 has two pass bands, and for example, the pass band A is the pass band by the TEM mode band pass filter while the pass band B is the pass band by the TE mode band pass filter.

[0026] In the dielectric filter 1 of the above-mentioned construction, the inner conductor 4 provided in each through hole 3 is provided with the non-conductive portion 4a, and the respective resonance frequencies of the TEM mode dielectric resonators 16a, 16b and the electromagnetic coupling therewith can be regulated by appropriately setting the dimensions and the arrangement positions of the non-conductive portion 4a. Thus, the band pass width and the center frequency of the TEM mode band pass filter can be changed.

[0027] On the other hand, the electromagnetic coupling between the TE mode dielectric resonators 15a, 15b can be regulated by appropriately setting the number and dimensions of the line conductor 7 provided on the open end surface 2a of the dielectric block 2 or the arrangement position, etc., on the open end surface 2a. Thus, the band pass width and the center frequency of the TE mode band pass filter can be changed.

[0028] Thus, in the dielectric filter 1, an electromagnetic affection by the line conductor 7 formed on the open end surface 2a is suppressed, because the non-

conductive portion 4a to regulate the respective resonance frequencies of the TEM mode dielectric resonators 16a, 16b and the electromagnetic coupling therewith is provided in the through hole 3. Further, no electrode pattern is formed on the open end surface 2a of the dielectric block 2 except the line conductor 7, and the limit on the position for forming the line conductor 7 is not strict, and the degree of freedom in setting the resonance frequencies of the TE mode dielectric resonators 15a, 15b is high. As a result, a compact dielectric filter 1 capable of independently designing the TEM mode band pass filter and the TE mode band pass filter can be obtained.

[Second Preferred Embodiment, FIG. 4 and FIG. 5]

[0029] As illustrated in FIG. 4, in a dielectric filter 21, three through holes 3 extending between an open end surface (a first surface) 2a and a short-circuited end surface (a second surface) 2b are formed in the dielectric block 2. The inner conductors 4 are formed on the inner wall surface of the through hole 3, and the inner conductors 4 are provided with the non-conductive portion 4a on the open end surface 2a. The outer conductors 25 are formed on the outer wall surface of the dielectric block 2 except the open end surface 2a and right and left side surfaces 2c, 2d.

[0030] The line conductor 7 leading from the first surface 2a of the dielectric block 2 to the second surface 2b is provided on the open end surface 2a and overlaps the through hole 3 located at the center. The line conductor 7 electrically connects an outer conductor part 25a provided on the upper surface (third surface) of the dielectric block 2 to an outer conductor portion 25b provided on the lower surface (fourth surface) on the open end surface 2a. An input electrode 27 common to the TE mode and the TEM mode, a TE mode output electrode 28, and a TEM mode output electrode 29 are provided on the right and left side surfaces (fifth and sixth surfaces) 2c, 2d of the dielectric block 2 with a gap to an outer conductor 25.

[0031] Three through holes 3 and their inner conductors 4 constitute three TEM mode dielectric resonators 16a, 16b, 16c of $1/4$ wavelength together with the outer conductors 25 and the dielectric block 2. The TEM mode dielectric resonators 16a-16c are electromagnetically coupled with each other to form the three-stage band pass filter of TEM mode. The outer conductors 5 and the dielectric block 2 constitute two TE mode dielectric resonators 15a, 15b divided by the line conductor 7.

[0032] FIG. 5 is an electric equivalent circuit of the dielectric filter 21. The dielectric filter 21 is a dielectric filter for the dual band of one-input/two-output type in which the TEM mode band pass filter, and the TE mode band pass filter are built in.

[0033] The dielectric filter 21 for the dual band of two-input/two-output type of the above-mentioned construc-

tion functions the similar effect to that of the dielectric filter 1 in the first preferred embodiment, and functions an electromagnetic wall of large reflection coefficient because no outer conductors are formed on the right and left side surfaces 2c, 2d of the dielectric block 2. Thus, the TE mode dielectric resonators 15a, 15b can be miniaturized, and the size of the dielectric block 2 can be reduced. Further, even when the line conductor 7 is overlapped on the through holes 3 to be formed into the open end surface 2a, the inner conductors 4 are provided with the non-conductive portion 4a in the vicinity of the open end surface 2a, and there is no concern that the open surface of the TEM mode dielectric resonator 16b is short-circuited by the line conductor 7. Thus, the position for forming the line conductor 7 is not limited on the open end surface 2a, and the degree of freedom of setting the resonance frequency of the TE mode dielectric resonators 15a, 15b is high.

[Third Preferred Embodiment, FIG. 6 and FIG. 7]

[0034] As illustrated in FIG. 6, a dielectric filter 31 is provided with an approximately rectangular parallelepiped dielectric block 32. Two through holes 3 extending between an open end surface 32a to an open end surface 32b are provided respectively on right and left side surface of the dielectric block 32. The inner conductors 4 are provided respectively on the inner wall surface of the through holes 3, and the inner conductors 4 are provided with the non-conductive portions 4a, 4b in the vicinity of the open end surface 32a and in the vicinity of the open end surface 32b.

[0035] Grooves 37a, 37b for coupling are provided opposite to each other in center portions of the open end surfaces 32a, 32b of the dielectric block 32. The grooves 37a, 37b for coupling are extended from the upper surface to the lower surface of the dielectric block 32. In addition, a hole 38 for coupling as a coupling means is provided in the center parts of the dielectric block 32, i.e., between the grooves 37a, 37b for coupling. The inner conductor is provided on the inner wall surface of the hole 38 for coupling.

[0036] Outer conductors 35 are provided on substantially the entire outer wall surface of the dielectric block 32. The outer conductors 35 are provided on the wall surfaces of the grooves 37a, 37b for coupling, and the inner conductors of the hole 38 for coupling are conducted to the outer conductors 35 at each end. An input electrode 39 common to the TE mode and the TEM mode, a TE mode output electrode 40, and a TEM mode output electrode 41 are formed with a gap from the outer conductors 35.

[0037] Two through holes 3 and their inner conductors 4 constitute two TEM mode dielectric resonators 16a, 16b of $1/2$ wavelength with the open end surface 32a and the open end surface 32b of the dielectric block 32 being open together with the outer conductors 35 and the dielectric block 32. The TEM mode dielectric

resonators 16a, 16b are electromagnetically coupled with each other to constitute the two-stage band pass filter of TEM mode.

[0038] Grooves 37a, 37b for coupling provided on the dielectric block 32, and through holes 38 on which inner conductors are provided, are operated as the coupling susceptance. Thus, the outer conductors 35 and the dielectric block 32 constitute two TE mode dielectric resonators 15a, 15b divided by the grooves 37a, 37b for coupling and the through holes 38. The TE mode dielectric resonators 15a, 15b are electromagnetically coupled with each other through a part narrowed by the grooves 37a, 37b for coupling of the dielectric block 32 and the hole 38 for coupling to form a two-stage band pass filter of TE mode. That is, the grooves 37a, 37b for coupling and the hole 38 for coupling not only electromagnetically couple the TE mode dielectric resonators 15a, 15b, but also function as electromagnetic boundary parts of large reflection coefficient of the resonators 15a, 15b. Both the grooves 37a, 37b for coupling and the through hole 38 are not necessarily provided, and similar effect can be obtained with a device provided with either of the grooves 37a, 37b for coupling or the through hole 38.

[0039] FIG. 7 is an electric equivalent circuit of the dielectric filter 31. The dielectric filter 31 is a dual band dielectric filter of one-input/two-output type in which the TEM mode band pass filter and the TE mode band pass filter are built.

[0040] In the dielectric filter 31 of the above-mentioned construction, the inner conductors 4 provided on the respective through holes 3 are provided with non-conductive portions 4a, 4b, and the respective resonance frequencies of the TEM mode dielectric resonators 16a, 16b and the electromagnetic coupling therewith can be regulated by appropriately setting the dimensions and the arrangement position of the non-conductive portions 4a, 4b. Thus, the pass band width, the center frequency, etc., of the TEM mode band pass filter can be changed.

[0041] On the other hand, the electromagnetic coupling between the TE mode dielectric resonators 15a, 15b can be regulated by appropriately setting the number, dimensions or arrangement position of the grooves 37a, 37b for coupling which are respectively provided on the open end surfaces 32a, 32b of the dielectric block 32, and the through hole 38 for coupling provided in the center part of the dielectric block 32. Thus, the pass band width and the center frequency of the TE mode band pass filter can be changed.

[0042] Because the dielectric filter 31 is provided with the non-conductive portions 4a, 4b to regulate the respective resonance frequencies of the TEM mode dielectric resonators 16a, 16b and the electromagnetic coupling therewith in the through holes 3, an electromagnetic affection by the open end surfaces 32a, 32b, the grooves 37a, 37b for coupling and the through hole 38 for coupling which are provided in the center part of

the dielectric block 32 is suppressed. As a result, the dielectric filter 31 capable of independently designing the TEM mode band pass filter and the TE mode band pass filter can be obtained.

[Fourth Preferred Embodiment, FIG. 8 and FIG. 9]

[0043] A fourth preferred embodiment describes a dielectric duplexer for use in a mobile communication equipment such as a mobile phone and a portable phone. As illustrated in FIG. 8, the dielectric filter 51 is provided with a rectangular parallelepiped dielectric block 52 made of the dielectric material. Four through holes 53a, 53b, 53c, 53d extending between an open end surface 52a and an open end surface 52b are provided in a row in the dielectric block 52. Inner conductors 54 are formed respectively on the inner wall surface of the through holes 53a-53d, and the inner conductors 54 are provided with non-conductive portions 54a on the open end surface 52a side. In addition, an outer coupling hole 63 extending between a center part of the open end surface 52a of the dielectric block 52 and a center part of the open end surface 52b is provided between the through holes 53b, 53c. Inner conductors are provided on the inner wall surface of the outer coupling hole 63.

[0044] An outer conductor 55 are provided on an outer wall surface of the dielectric block 52 except for the open end surface 52a. That is, in the outer conductor 55, outer conductor portions 55a, 55c are provided on the right half and the left half securing a gap on the upper surface of the dielectric block 52, while outer conductor parts 55b, 55d are provided on the right half and the left half securing the prescribed gap on the lower surface of the dielectric block 52. The outer conductor 55 is electrically opened (disconnected) from the inner conductors 54 of the through holes 53a-53d on the open end surface 52a of the dielectric block 52, and electrically short-circuited (conducted) with the inner conductors 54 on the short-circuit side end surface 52b.

[0045] A line conductor 57 leading from an upper surface of the dielectric block 52 to the lower surface thereof is provided on the open end surface 52a between through holes 53a, 53b, and line conductors 58, 59 leading from the upper surface to the lower surface of the dielectric block 52 are provided on the open end surface 52a and overlap through holes 53c, 53d. The line conductor 57 electrically connects the outer conductor portion 55a provided on the upper surface of the dielectric block 52 to the outer conductor 55b provided on the lower surface on the open end surface 52a. The line conductors 58, 59 respectively and electrically connect an outer conductor part 56a provided on the upper surface of the dielectric block 52 to an outer conductor part 56b provided on the lower surface thereof on the open end surface 52a.

[0046] A receiving electrode Rx and a transmission electrode Tx which are input electrodes common to the

TE mode and the TEM mode are provided on right and left side parts of the dielectric block 52 with a gap to the outer conductor 55. An antenna electrode ANT which is an input electrode common to the TE mode and the TEM mode is provided in the center portion of the open end surface 52a of the dielectric block 52 in a conducted manner to the inner conductor in an outer coupling hole 63. That is, the inner conductor in the outer coupling hole 63 is electrically disconnected to the outer conductor 55 on the open end surface 52a, and electrically conducted with the outer conductor 55 on the short-circuited end surface 52b.

[0047] Two through holes 53a, 53b and their inner conductors 54 constitute two TEM mode dielectric resonators 16a, 16b of $1/4$ wavelength with the open end surface 52a and the short-circuit side end surface 52b of the dielectric block 52 being the open surface and the short-circuit surface together with the respective left halves of the outer conductor 55 and the dielectric block 52. The TEM mode dielectric resonators 16a, 16b are electromagnetically coupled with each other to form the two-stage band pass filter of TEM mode.

[0048] The line conductor 57 provided on the open end surface 52a of the dielectric block 52 functions as the coupling susceptance. Thus, the respective left halves of the outer conductor 55 and the dielectric block 52 constitute two TE mode dielectric resonators 15a, 15b divided by the line conductor 57. The TE mode dielectric resonators 15a, 15b are electromagnetically coupled with each other through the line conductor 57 to form the two-stage band pass filter of the TE mode. That is, the line conductor 57 not only electromagnetically couples the TE mode dielectric resonators 15a, 15b, but also functions as an electromagnetic boundary part of large reflection coefficient of the resonators 15a, 15b.

[0049] Two through holes 53c, 53d and their inner conductors 54 constitute two TEM mode dielectric resonators 16c, 16d of $1/4$ wavelength with the open end surface 52a and the short-circuit side end surface 52b of the dielectric block 52 being the open surface and the short-circuit surface together with the respective right halves of the outer conductor 55 and the dielectric block 52. The TEM mode dielectric resonators 16c, 16d are electromagnetically coupled with each other to form the two-stage band pass filter of the TEM mode.

[0050] The line conductors 58, 59 provided on the open end surface 52a of the dielectric block 52 function as the coupling susceptance. Thus, the respective right halves of the outer conductor 55 and the dielectric block 52 constitute three TE mode dielectric resonators 15c, 15d, 15e divided by the line conductors 58, 59. The TE mode dielectric resonators 15c-15e are electromagnetically coupled with each other through the line conductors 58, 59 to form a three-stage band pass filter of the TE mode.

[0051] In the dielectric duplexer 51 of the above-mentioned construction, the resonators 15c-15e, 16c, 16d

arranged on the right half of the dielectric block 52 form a transmission filter 60A. The resonators 15a, 15b, 16a, 16b arranged on the left half of the dielectric block 52 form a transmission filter 60B. The dielectric duplexer 51 outputs the transmission signal received by the transmission electrode Tx from the transmission circuit system not shown in the figure from the antenna electrode ANT through the transmission filter 60A, and outputs the reception signal received by the antenna electrode ANT from the receiving electrode Rx to the reception circuit system not shown in the figure through the reception filter 60B. FIG. 9 is an electric equivalent circuit of the dielectric duplexer 51.

[0052] In the dielectric duplexer 51, the inner conductors 54 provided in the through holes 53a-53d are provided with the non-conductive portion 54a, and the respective resonance frequencies of the TEM mode dielectric resonators 16a-16d and the electromagnetic coupling therewith can be regulated by appropriately setting the dimension and the arrangement position of the non-conductive portion 54a. Thus, the pass band width and the center frequency of the TEM mode band pass filter can be changed. On the other hand, the electromagnetic coupling of the TE mode dielectric resonators 15a-15e therewith can be regulated by appropriately setting the number and dimensions of the line conductors 57-59 provided on the open end surface 52a of the dielectric block 52 and the arrangement position on the open end surface 52a. Thus, the pass band width and the center frequency of the TE mode band pass filter can be changed.

[0053] The dielectric duplexer 51 is provided with the non-conductive portion 54a to regulate the respective resonance frequencies of the TEM mode dielectric resonators 16a-16d and the electromagnetic coupling therewith in the through holes 53a-53d, and electromagnetically affected with difficulty by the line conductors 57-59 to regulate the electromagnetic coupling between the TE mode dielectric resonators formed on the open end surface 52a. Further, on the open end surface 52a of the dielectric block 52, the limit of the forming position of the line conductors 57-59 is not strict, and the degree of freedom in setting the resonance frequencies of the TE mode dielectric resonators 15a-15e is high. As a result, a compact dielectric duplexer 51 capable of independently designing the TEM mode band pass filter and the TE mode band pass filter can be obtained.

[Other Preferred Embodiments]

[0054] The dielectric filter and the dielectric duplexer of the present invention are not limited to the above-mentioned embodiments, but can be variously changed in the scope of the subject matter of the present invention.

[0055] In the above-described embodiments, the dielectric filter and the dielectric duplexer in which the TEM

mode band pass filter and the TE mode band pass filter are built, are described. However, because the structure of the TE mode band pass filter is same as the structure of the TM mode band pass filter, the dielectric filter and the dielectric duplexer in each embodiment can be handled as the dielectric filter and the dielectric duplexer in which the TM mode band pass filter and the TE mode band pass filter are built by inputting the TM mode signal in place of the TE mode.

[0056] Further, in the dielectric duplexer 51 in the fourth preferred embodiment, a through hole for coupling or a groove for coupling may be provided in place of the line conductors 57-59, and the inner conductors 54 in the through holes 53a-53d may have an non-conductive portion also in the vicinity of the short-circuit side end surface 52b.

[0057] While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the forgoing and other changes in form and details may be made therein without departing from the spirit of the invention.

Claims

1. A dielectric filter (1; 21), comprising:

- a dielectric block (2) having substantially rectangular shape, said dielectric block (2) including a first and a second surfaces (2a, 2b) opposed to each other and a third and a fourth surfaces opposed to each other and extending between said first and second surfaces (2a, 2b);
- a plurality of through holes (3) extending between said first (2a) and second (2b) surfaces;
- an inner conductor (4) provided on an inner surface of said through holes (3) except for a non-conductive portion (4a), said non-conductive portion (4a) being disposed on said inner surface of said through holes (3) in the vicinity of said first surface (2a) of said dielectric block (2);
- an outer conductor (5; 25) provided on said third and fourth surfaces of said dielectric block (2); and
- a line conductor (7) provided on said first surface (2a) of said dielectric block (2), a part (5a; 25a) of said outer conductor (5; 25) provided on said third surface of said dielectric block (2) and a part (5b; 25b) of said outer conductor (5; 25) provided on said fourth surface of said dielectric block (2) being connected to each other via said line conductor (7);
- thereby a plurality of resonators comprising a combination of a TEM mode resonator (16a, 16b; 16a, 16b, 16c) and a TE mode resonator

(15a, 15b), or a combination of a TEM mode resonator or a TM mode resonator being provided.

2. A dielectric filter (31), comprising:

a dielectric block (32) having substantially rectangular shape, said dielectric block (32) including a first and a second surfaces (32a, 32b) opposed to each other and a third and a fourth surfaces opposed to each other and disposed between said first and second surfaces (32a, 32b);

a plurality of through holes (3) extending between said first and second surfaces;

an inner conductor (4) provided on an inner surface of said through holes (3) except for a non-conductive portion (4a, 4b), said non-conductive portion (4a, 4b) being disposed on said inner surface of said through holes (3) in the vicinity of said first surface (32a) of said dielectric block (32);

an outer conductor (35) provided on said third and fourth surfaces of said dielectric block (32); and

at least one of a coupling means (38) and a coupling groove (37a, 37b);

said coupling means (38) extending between said third and fourth surfaces of said dielectric block (32), a part of said outer conductor (35) provided on said third surface of said dielectric block (32) and a part of said outer conductor (35) provided on said fourth surface of said dielectric block (32) being connected to each other via said coupling means (38);

said coupling groove (37a, 37b) being disposed on said first and second surfaces (32a, 32b) of said dielectric block (32) and extending between said third and fourth surfaces of said dielectric block (32);

thereby a plurality of resonators comprising a combination of a TEM mode resonator (16a, 16b) and a TE mode resonator (15a, 15b), or a combination of a TEM mode resonator (16a, 16b) or a TM mode resonator being provided.

3. The dielectric filter (31) according to Claim 2, wherein

said non-conductive portion (4a, 4b) is also disposed on said inner surface of said through holes (3) in the vicinity of said second surface (32b) of said dielectric block (32).

4. The dielectric filter (31) according to one of Claims 1 to 3, wherein:

said dielectric filter (31) further includes a fifth

and a sixth surfaces opposed to each other and extending between said first and second surfaces (32a, 32b); and

input/output external electrodes (39, 40, 41) are provided on said fifth and sixth surfaces of said dielectric block (32).

5. A dielectric duplexer, comprising:

a dielectric block (2) having substantially rectangular shape, said dielectric block (2) including a first and a second surfaces (2a, 2b) opposed to each other and a third and a fourth surfaces opposed to each other and extending between said first and second surfaces (2a, 2b);

a plurality of through holes (3) extending between said first (2a) and second (2b) surfaces;

an inner conductor (4) provided on an inner surface of said through holes (3) except for a non-conductive portion (4a), said non-conductive portion (4a) being disposed on said inner surface of said through holes (3) in the vicinity of said first surface (2a) of said dielectric block (2);

an outer conductor (5; 25) provided on said third and fourth surfaces of said dielectric block (2); and

a line conductor (7) provided on said first surface (2a) of said dielectric block (2), a part (5a; 25a) of said outer conductor (5; 25) provided on said third surface of said dielectric block (2) and a part (5b; 25b) of said outer conductor (5; 25) provided on said fourth surface of said dielectric block (2) being connected to each other via said line conductor (7);

thereby a plurality of resonators comprising a combination of a TEM mode resonator (16a, 16b; 16a, 16b, 16c) and a TE mode resonator (15a, 15b), or a combination of a TEM mode resonator or a TM mode resonator being provided.

6. A dielectric duplexer (51), comprising:

a dielectric block (52) having substantially rectangular shape, said dielectric block (52) including a first and a second surfaces (52a, 52b) opposed to each other and a third and a fourth surfaces opposed to each other and disposed between said first and second surfaces (52a, 52b);

a plurality of through holes (53a, 53b, 53c, 53d) extending between said first and second surfaces (52a, 52b);

an inner conductor (54) provided on an inner surface of said through holes (53a-d) except for

a non-conductive portion (54a), said non-conductive portion (54a) being disposed on said inner surface of said through holes (53a-d) in the vicinity of said first surface (52a) of said dielectric block (52);

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an outer conductor (55) provided on said third and fourth surfaces of said dielectric block (52); and

at least one of a coupling means (57, 58, 59) and a coupling groove;

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said coupling means (57, 58, 59) extending between said third and fourth surfaces of said dielectric block (52), a part of said outer conductor (55) provided on said third surface of said dielectric block (52) and a part of said outer conductor (55) provided on said fourth surface of said dielectric block (52) being connected to each other via said coupling means (57, 58, 59);

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said coupling groove being disposed on said first and second surfaces (52a, 52b) of said dielectric block (52) and extending between said third and fourth surfaces of said dielectric block (52);

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thereby a plurality of resonators (15a, 15b, 15c, 15d, 15e, 16a, 16b, 16c, 16d) comprising a combination of a TEM mode resonator and a TE mode resonator, or a combination of a TEM mode resonator or a TM mode resonator being provided.

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7. The dielectric duplexer (51) according to Claim 6, wherein

said non-conductive portion is also disposed on said inner surface of said through holes (53a-d) in the vicinity of said second surface (52b) of said dielectric block (52).

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8. The dielectric duplexer (51) according to one of Claims 5 to 7, wherein:

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said dielectric filter further includes a fifth and a sixth surfaces opposed to each other and extending between said first and second surfaces (52a, 52b); and input/output external electrodes (Rx, Tx, ANT) are provided on said fifth and sixth surfaces of said dielectric block (52).

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FIG.1

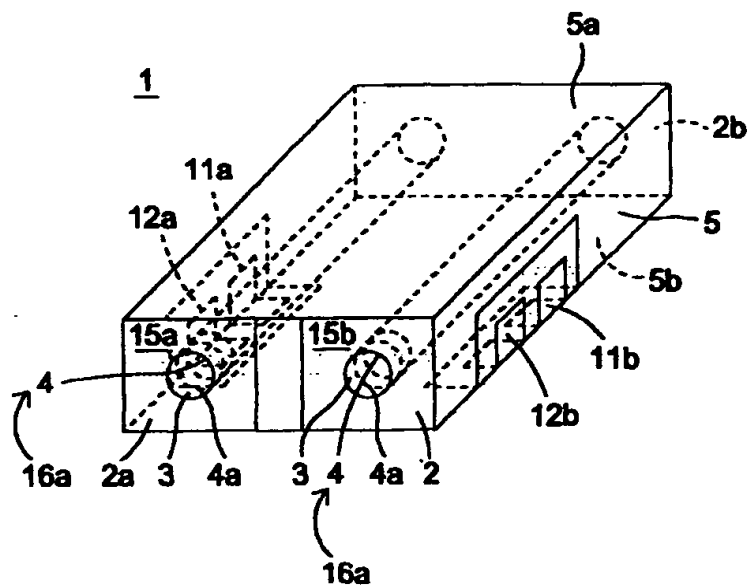


FIG.2

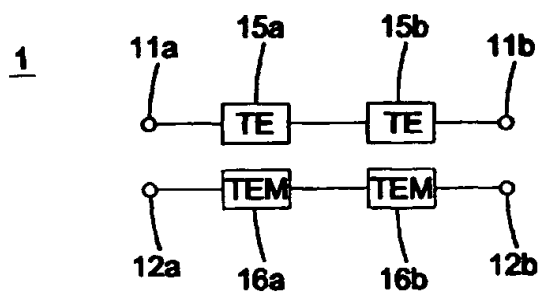


FIG.3

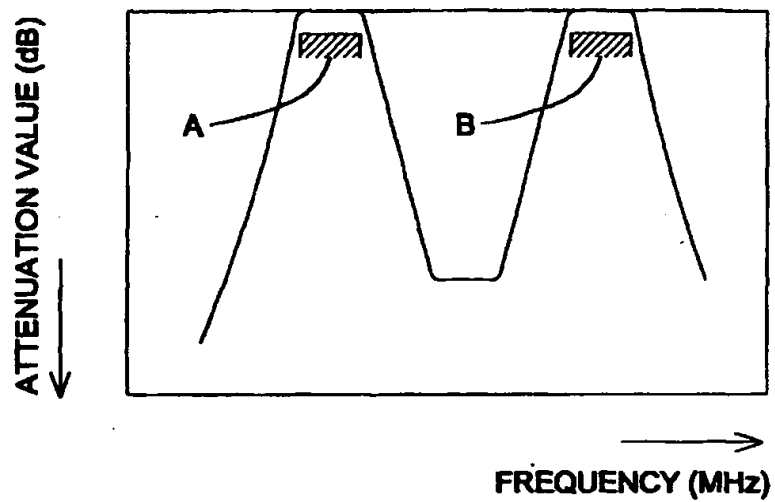


FIG.4

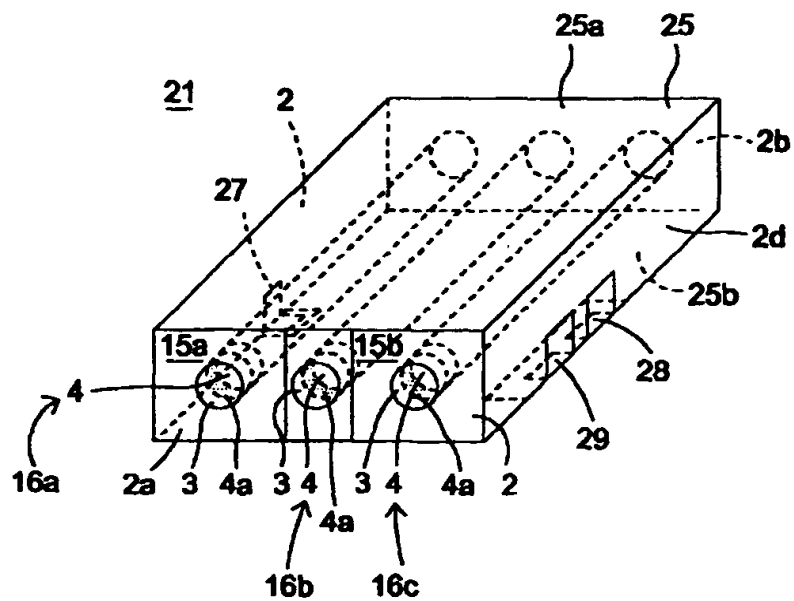


FIG.5

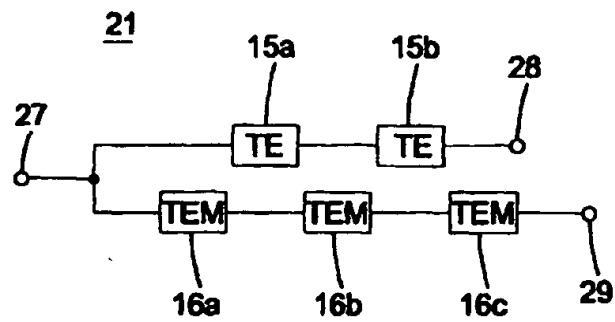


FIG.6

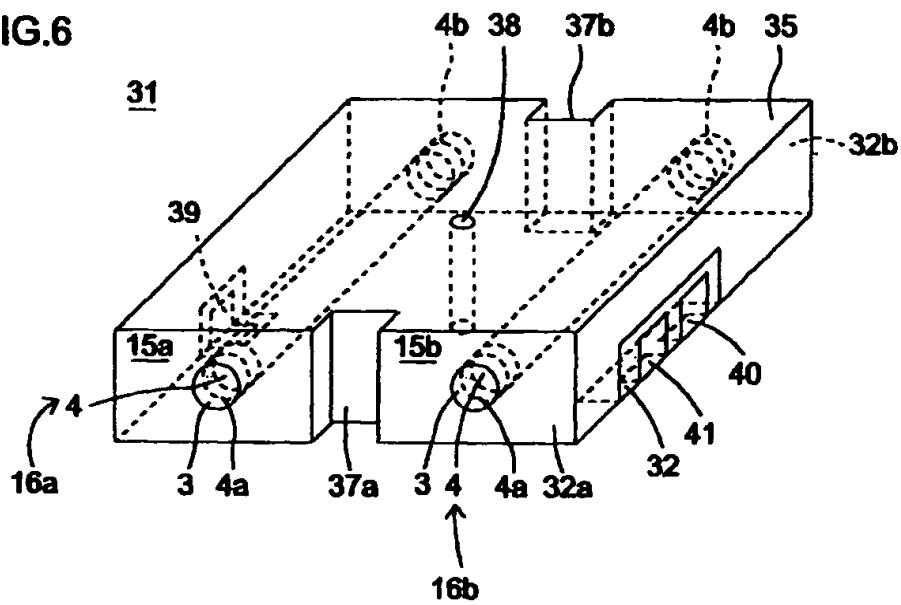


FIG.7

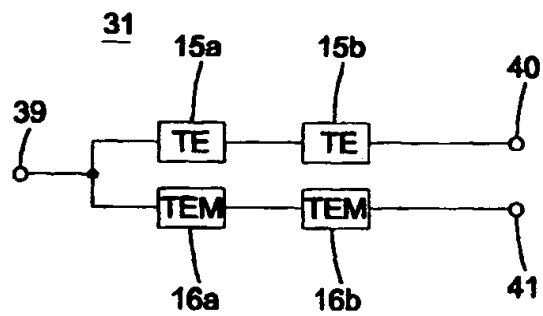


FIG. 8

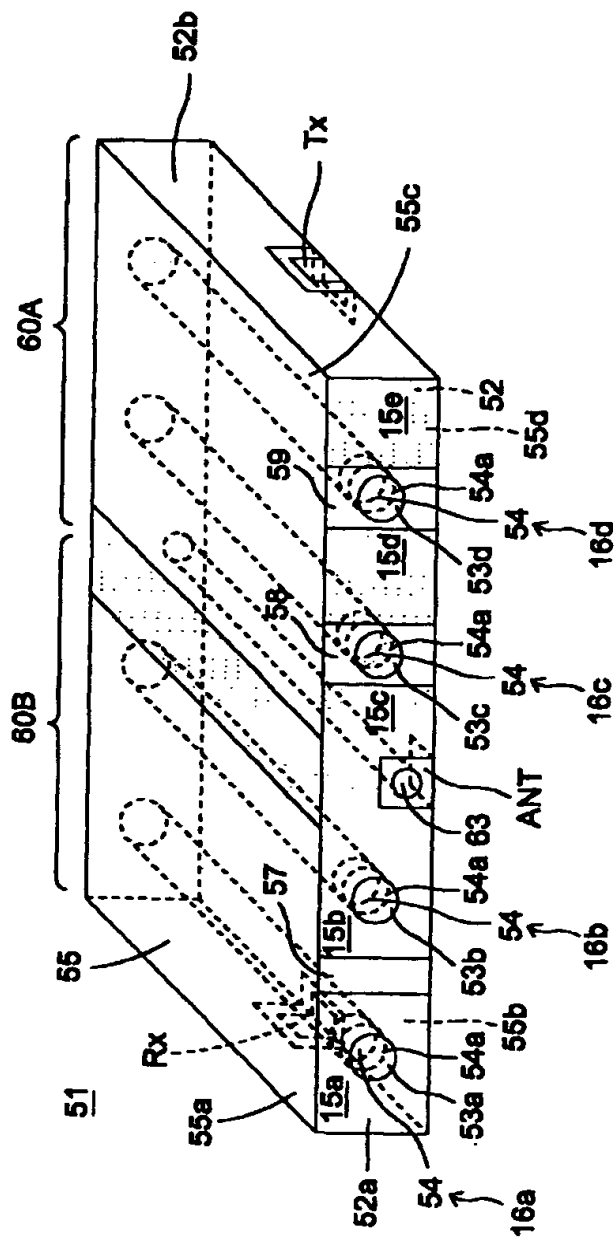


FIG.9

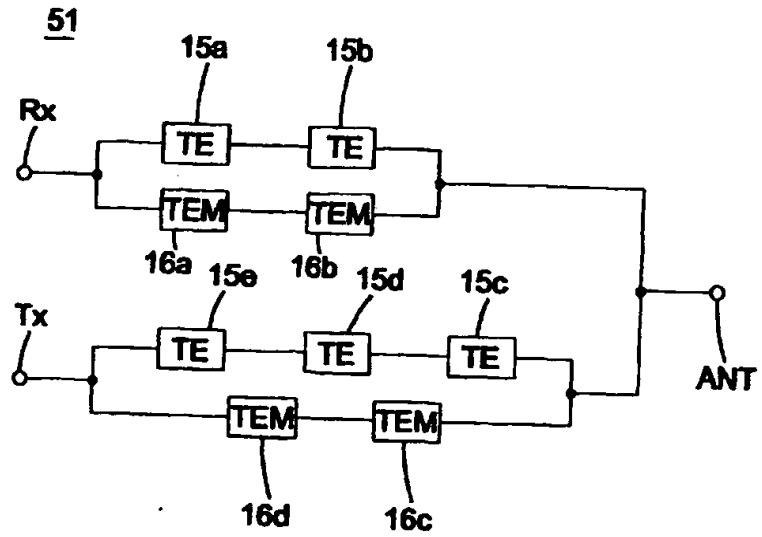


FIG.10

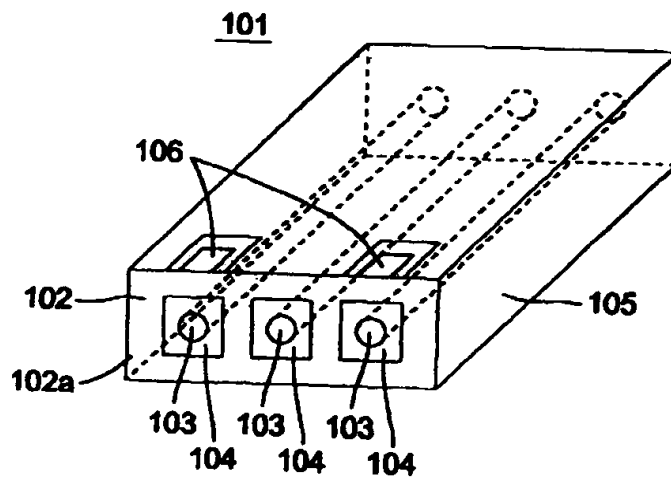
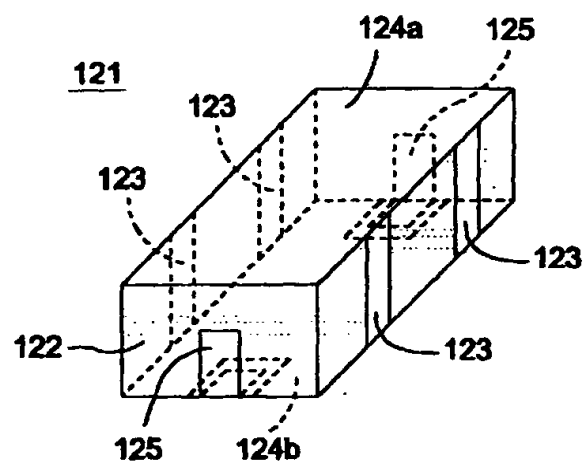


FIG.11





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 12 4542

| DOCUMENTS CONSIDERED TO BE RELEVANT | | | |
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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.8) |
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| | | | TECHNICAL FIELDS SEARCHED (Int.Cl.8) |
| | | | H01P |
| The present search report has been drawn up for all claims | | | |
| Place of search THE HAGUE | | Date of completion of the search 24 March 1999 | Examiner Den Otter, A |
| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p> | | | |

EPO FORM 1503 03.92 (P04031)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 98 12 4542

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The members are as contained in the European Patent Office EDP file on
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24-03-1999

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| WO 9702618 | A | 23-01-1997 | US | 5731746 A | 24-03-1998 |